CATALOG DOCUMENTATION
EMAP-GREAT LAKES PROGRAM LEVEL DATABASE
1994 LAKE SUPERIOR NEARSHORE
CHLOROPHYLL DATA

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1. DATA SET IDENTIFICATION

1.1 Title of Catalog document

EMAP-Great Lakes Program Level Database
1994 Lake Superior Nearshore
Chlorophyll Data

1.2 Authors of the Catalog entry

Sharon Bertelsen, U.S. EPA NHEERL-MED
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1.3 Catalog revision date

4 November 1996

1.4 Data set name

LSCHL94

1.5 Task Group

Great Lakes

1.6 Data set identification code

521

1.7 Version

001

1.8 Requested Acknowledgment

These data were produced as part of the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP). If you plan to publish these data in any way, EPA requires a standard statement for work it has supported:

"Although the data described in this article has been funded wholly or in part by the U.S. Environmental Protection Agency through its EMAP-Great Lakes Program, it has not been subjected to Agency review, and therefore does not necessarily reflect the views of the Agency and no official endorsement should be inferred."

2. INVESTIGATOR INFORMATION

2.1 Principal Investigator

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3. DATA SET ABSTRACT

3.1 Abstract of the Data Set

The Lake Superior Chlorophyll data set provides chlorophyll concentrations at twenty-seven sampling stations located along the southern shore of the nearshore region of Lake Superior. Chlorophyll analysis was conducted on thermally stratified water samples collected from the surface, mid-epilimnion, and upper hypolimnion.

Samples were filtered and pigments were solvent extracted with an acetone-DMSO solvent. Spectrophotometric analysis was performed using monochromatic and trichromatic methods for determination of chlorophyll a, carotenoid pigments, and pheophytins. Chlorophylls b and c were determined trichromatically.

3.2 Keywords for the Data Set

Chlorophyll, nearshore region, spectrophotometric analysis, Great Lakes, Lake Superior

4. OBJECTIVES AND INTRODUCTION

4.1 Program Objective

The Environmental Monitoring and Assessment Program (EMAP) was designed to periodically estimate that status and trends of the Nation's ecological resources on a regional basis. EMAP provides a strategy to identify and bound the extent, magnitude and location of environmental degradation and improvement on a regional scale based on station sites randomly located in the Great Lakes. Base grid and three-fold enhanced sampling sites from nearshore Lake Superior are included in this data set.

4.2 Data Set Objective

The primary objective of the chlorophyll data set is to characterize the trophic status endpoint by providing estimates of phytoplankton biomass and serving as an indicator of aquatic productivity in the Great Lakes. Chlorophyll measurements were also used to calibrate an in situ fluorometer and interpret remotely-sensed AVHRR data.

4.3 Background Discussion

Condition indicators provide important information about ecological condition of a sampling site. Chlorophyll a is an important factor addressing the trophic status of an ecosystem. Chlorophyll a is the primary photosynthetic pigment of algae and provides an estimate of algal biomass, which can be used as an indication of productivity. Consequently, its absorbance is measured most frequently. Also, the absorbance of chlorophylls b and c, accessory pigments, and pheophytins can also be measured. If an entire suite of pigments is analyzed, pigment analysis will provide the ability to differentiate algal biomass from other organic constituents in the assemblage, and provide information on algal community structure.

The amount of chlorophyll in an algal cell can change depending on

ambient conditions. It readily responds to natural and anthropogenic influenced stressors such as nutrient levels and light attenuation characteristics. Turbidity levels, particularly from increases in suspended solids, can affect light penetration depth and intensity. This can cause an effect on the algal community to carry out photosynthesis. Since algal abundance and productivity is the energy base for an autochthonous system, any changes can have impacts on the food web dynamics. Other water chemistry and abiotic parameters were measured which will be helpful with chlorophyll a data interpretation.

4.4 Summary of Data Set Parameters

Chlorophyll a (monochromatic and trichromatic methods), chlorophylls b and c (trichromatic methods) carotenoids, and pheophytins are reported for surface, mid-epilimnion, and upper hypolimnion at each sampling station.

5. DATA ACQUISITION AND PROCESSING METHODS

5.1 Data Acquisition

5.1.1 Sampling Objective

To collect water samples from 27 sampling sites from the nearshore region of Lake Superior. A 4 L Van Dorn sampler was used to collect water samples from a thermally stratified water column. Discrete samples were collected from the surface (1m), mid-epilimnion, and upper hypolimnion. At stations with isothermal conditions, water samples were collected at 1 and 10 meters.

5.1.2 Sample Collection Methods Summary

At all stations, depth and temperature profiles for the water column were determined using a Sea Bird SBE 19 CTD, and a 4 L Van Dorn sampler was used to collect thermally stratified (surface, mid-epilimnion, and upper hypolimnion) water samples or, in some cases, samples were collected in a isothermally stratified column.

The water samples were subsampled for chlorophyll measurements by obtaining a two liter sample from each depth and placing the subsample into separate opaque polyethylene bottles and refrigerated for filtration. Each sample was filtered through a 0.45 membrane filter (Millipore type HA, 47 mm diameter). Using a vacuum filtration apparatus, pressure was maintained at no more than 0.5 atms. The filters were folded into quarters, wrapped in aluminum foil, and frozen for storage until laboratory analysis.

5.1.3 Beginning Sampling Date

8 August 1994

5.1.4 Ending Sampling Date

20 August 1994

5.1.5 Platform

Sampling was conducted from a 76 meter research vessel, the R/V Explorer, owned and operated by the U.S. EPA, NHEERL-MED.

5.1.6 Sampling Equipment

A 4 L Van Dorn water sampler was used to collect water samples. Opaque polyethylene containers were used for subsamples. A 2000 Liter graduated cylinder was used for measuring subsample volume for filtering. A filtering apparatus with a vacuum pump was used for filtering samples. Millipore type HAWP 0.45 membrane filters (47 mm diameter) were used for collecting algal biomass.

5.1.7 Manufacturer of Instrument

5.1.8 Key Variables

This data set contains surface, mid-epilimnion, and upper hypolimnion values. Two sites had duplicate field samples and are averaged for each discrete depth.

5.1.9 Collection Method Calibration

The sampling gear required no calibration.

5.1.10 Collection Quality Control

Duplicate field samples at 2 sites (10% of sites) were taken.

5.1.11 Sample Collection Method Reference

Strobel, C.J. and S.C. Schimmel, 1991. Environmental Monitoring and Assessment Program-Near Coastal. 1991 Virginian Province, Field Operations and Safety Manual. U.S. EPA, NHEERL-AED, Narragansett, RI. June 1991.

5.2 Data Processing and Sample Processing

5.2.1 Sample Processing Objective

To process chlorophyll samples to characterize algal biomass in terms of chlorophyll a.

5.2.2 Sample Processing Methods Summary

The chlorophyll samples were stored as frozen filters wrapped in aluminum foil until analysis. Spectrophotometric analysis was used for chlorophyll determination, and monochromatic and trichromatic methods were used for detection of chlorophylls a, b, and c, carotenoid pigments, and pheophytin. The filters were placed in 20 ml scintillation vials and solvent extracted for 20-24 hours. The solvent used was an acetone-DMSO mixture. Analysis was performed in subdued light using a Perkin Elmer Lambda 2S Spectrophotometer using a 5 cm path length cell. Blanks and standards were run prior to and at the end of analysis for background correction. Samples were acidified with 1 N HCL for pheophytin correction.

5.2.3 Sample Processing Method Calibration

Analysis of chlorophyll samples, standards, and blanks were performed in subdued light. Samples were allowed to warm to room temperature. An initial blank was analyzed prior to sample analysis for background correction. Solvent absorbances were read to verify zero readings. If zero readings were not obtained, the sequence was repeated. If zero readings were obtained, solvent was drawn into the cell and read to verify a stable reading of zero.

5.2.4 Sample Processing Quality Control

Blanks and standards were analyzed before, during, and at end of analysis.

5.2.5 Sample Processing Method Reference

Standard methodology was used with DMSO extraction procedure. Reference follows:
Shoaf, W.T. and B.W. Lium. 1976. Improved extraction of chlorophyll a and b from algae using dimethyl sulfoxide. Limnol. Oceanogr. 21:926-928.

5.2.6 Sample Processing Method Deviations

6. DATA ANALYSIS AND MANIPULATIONS

6.1 Name of New or Modified Values

6.2 Data Manipulation Description

The formulas used for calculating chlorophyll, carotenoid, and pheophytin using the monochromatic and trichromatic procedures follow:

Monochromatic Method (Lorenzen, 1967):

$$\text{Chl a (g/L or mg/m) } = \frac{(k)\ (F)\ (E665o - E665a)\ (v)}{(V)\ (Z)}$$

where
E665o = turbidity-corrected absorption at 665 nm before acidification
= A665o - A750o, where A = the absorption value
E665a = turbidity-corrected absorption at 665 nm after acidification =
A665a - A750a
k = absorption coefficient of chlorophyll a, = 11.0
F = factor to equate the reduction in absorbency to initial chlorophyll concentration, 1.7:0.7, or = 2.43
R = maximum ration of E665o:E665a in the absence of pheopigments, = 1.7
v = volume of extract in ml
V = volume of water filtered in liters
Z = length of light path trough cuvette or cell in cm.

$$\text{Pheopigments (g/L or mg/m) } = \frac{(k)\ (F)\ R\ (E665a - E665o)\ (v)}{(V)\ (Z)}$$

6.2 Data Manipulation Description, continued

Trichromatic Method (Jeffery and Humphrey, 1975):

$$\text{Chl a (g/L or mg/m) } = \frac{(Ca)\ (v)}{(V)\ (Z)}$$

where Ca = 11.85 E664 1.54 E647 0.08 E630 and E6640 = A664 A750, etc., as above.

$$\text{Chl b (g/L or mg/m) } = \frac{(Cb)\ (v)}{(V)\ (Z)}$$

where Cb = 21.03 E647 5.43 E664 2.66 E630 and E6470 = A647 A750, etc., as above.

$$\text{Chl c1 + c2 (g/L or mg/m) } = \frac{(Cc)\ (v)}{(V)\ (Z)}$$

where Cc1 + 2 = 24.52 E630 1.67 E664 7.60 E647 and E630 = A630 A750, etc., as above.

From these data the amount of pigments per cell of phytoplankton can be estimated.

$$\text{g chl in extract} = (\text{g chl/ml})(\text{volume of extract, ml})$$

$$\text{mol of chl extract} = \frac{\text{g chl in extract}}{\text{molecular weight of chl}}$$

where the formula weights are chlorophyll a = 893.5, chlorophyll b = 907.5, and chlorophyll c = 610.

$$\text{mol of chl/cell} = \frac{\text{mol of chl extract}}{\text{number cells in sample}}$$

Plant Carotenoids (Strickland and Parsons, 1972):

$$\text{Car (SPU)/L or mSPU/m) } = \frac{(10.0)(E4800)(v)}{(V)\ (Z)}$$

where

SPU = specified plant pigment units approximating the mg

$$E4800 = A480 \quad (3)(A750)$$

Use the factor of 10.0 when the algae consist primarily of Chrysophyta, Pyrrophyta, or both. When the algae consist predominantly of members of Chlorophyta and/or Cyanophyta, then use the following equation:

$$\text{Car (SPU)/L or mSPU/m) } = \frac{(4.0)(E4800)(v)}{(V)\ (Z)}$$

where

$$E4800 = A4800 \quad (3)(A7500)$$

$$\text{Pheopigments (g/ or mg/m) } = \frac{(26.7)\ 1.7(E665a) \quad E6650\ (v)}{(V)\ (Z)}$$

6.3 Data Manipulation Examples

7. DATA DESCRIPTION

7.1 Description of Parameters

#	Name	Type	Length	Format	Parameter Label
1	STA_NAME	Char	8	8.	Station Name
2	DATE	Num	8	YYMMDD8.	Date the sample was collected
3	DEPTH_ C	Char	1	1.	Depth category of sample (E-mid epilimnion, H-upper hypolimnion, S-surface)
4	DEPTH	Num	5	5.	Depth (m)
5	CHLA_M	Num	6	6.2	Chlorophyll a (g/L), monochromatic method
6	CHLA_T	Num	6	6.2	Chlorophyll a (g/L), trichromatic method
7	CHLB_T	Num	6	6.2	Chlorophyll b (g/L), trichromatic method
8	CHLC_T	Num	6	6.2	Chlorophyll c (g/L), trichromatic method
9	CARO	Num	4	4.	Carotenoid (g/L) pigment
10	PHEO	Num	4	4.	Pheophytin (g/L)

7.1.1 Precision to which values are reported

The number of decimal places for each value reflects the precision of the spectrophotometer.

7.1.2 Minimum Value in Data Set

CHLA_M	0.29
CHLA_T	0.38
CHLB_T	0.04
CHLC_T	0.08
CARO	0.46
PHEO	0.0

7.1.3 Maximum Value in Data Set

CHLA_M	2.02
CHLA_T	2.66
CHLB_T	0.36
CHLC_T	0.79
CARO	2.79
PHEO	1.34

7.2 Data Record Example

7.2.1 Column Names for Example Records

STA_NAME, DATE, DEPTH_C, DEPTH, CHLA_M, CHLA_T, CHLB_T, CHLC_T, CARO, PHEO

7.2.2 Example Data Records

STA_NAME	DATE	DEPTH_C	DEPTH	CHLA_M	CHLA_T	CHLB_T	CHLC_T	CARO	PHEO
LS94-76401	940816	S	1	0.41	0.51	0.05	0.08	0.55	0.14
LS94-76401	940816	H	35	0.96	1.40	0.11	0.28	1.32	0.65
LS94-76401	940816	E	14	0.63	0.80	0.07	0.15	0.77	0.22

8. GEOGRAPHIC AND SPATIAL INFORMATION

8.1 Minimum Longitude

-91 deg 43.516' W

8.2 Maximum Longitude

-84 deg 45.036' W

8.3. Minimum Latitude

46 deg 26.420' N

8.4 Maximum Latitude

47 deg 18.180' N

8.5 Name of Area or Region

Nearshore Lake Superior
Stations were located along the southern shore of the Nearshore resource class of Lake Superior from Duluth, Minnesota to Sault Ste. Marie, Michigan. Nearshore sites were located within the 100 meter depth contour. The area includes Minnesota, Wisconsin, and Michigan.

9. QUALITY CONTROL/QUALITY ASSURANCE

9.1 Measurement Quality Objectives

9.2 Data Quality Assurance Procedures

9.3 Actual Measurement Quality

10. DATA ACCESS

10.1 Data Access Procedures

Data can be downloaded from the EMAP Website.

10.2 Data Access Restrictions

Not applicable.

10.3 Data Access Contact Persons

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10.4 Data Set Format

Data from the Website are in ASCII fixed format.

10.5 Information Concerning Anonymous FTP

Not accessible.

10.6 Information Concerning WWW

Data can be downloaded from the EMAP Website.

10.7 EMAP CD-ROM Containing the Data Set

Data are not available on CD-ROM.

11. REFERENCES

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Jeffrey, S.W. and G.F. Humphrey. 1975. New spectrophotometric equations for determining chlorophylls a, b, c1 and c2 in higher plants, algae, and natural phytoplankton. Biochem. Physiol. Pflanzen 167:191-194.

Strickland, J.D.H. and T.R. Parsons. 1972. A Practical Handbook of Seawater Analysis. 2nd Ed. Fisheries Research Board of Canada, Ottawa. 310 pp.

Hedtke, S., A. Pilli, D. Dolan, G. McRae, B. Goodno, R. Kreis, G. Warren, D. Swackhamer, and M. Henry. 1992. Great Lakes Monitoring and Research Strategy: Environmental Monitoring and Assessment Program. USEPA, Office of Research and Development, ERL-Duluth, Duluth, Minnesota. EPA/602/R-92/001. 204 p.

12. TABLE OF ACRONYMS

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